Research Product 86-31

A Self-Correcting Compass Course for Training Dead Reckoning

ARI Field Unit at Fort Benning, Georgia
Training Research Laboratory

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Dead reckoning involves navigating by distance (pace count) and direction (compass azimuth). The purpose of this paper is to describe a self-correcting compass course designed to train this skill. Additionally, a computer program has been written that can be used to generate the azimuth and distance for each leg of the course, facilitating course set up. The compass course can be easily modified to work in any training area to assist
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ARI Research Product 86-31

20. (Continued)

and reinforce training on dead reckoning. Similar courses have been used by the Rangers and Special Forces to increase soldiers' confidence in their navigational abilities. Advantages of the new course include its self-correcting aspect and the fact that the soldier is forced into using an accurate pace count.

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A Self-Correcting Compass Course for Training Dead Reckoning

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Training Land Navigation

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FOREWORD

As part of the U.S. Army land navigation training, every soldier learns to use a compass and measure distance using a pace count. This form of navigation is called dead reckoning. Although dead reckoning is an important navigational technique, effective means for developing azimuth and distance determination skills are lacking.

In response to this problem, the Army Research Institute, in cooperation with the U.S. Army Infantry Center at Fort Benning, Georgia, developed a self-correcting compass course, which can be used in a parking lot or in a field and which is designed to test a soldier's ability to use a compass and pace count. An accompanying computer program that enables the instructor to specify training area dimensions and that provides randomly generated azimuths and distances for the course set-up was written.

EDGAR M. JOHNSON
Technical Director

A SELF-CORRECTING COMPASS COURSE FOR TRAINING DEAD RECKONING

EXECUTIVE SUMMARY

Requirement:

All soldiers need to know how to use a compass and to determine distance using a pace count. However, there is currently a lack of effective means to train these dead-reckoning skills. In response to this need, a compass course that can be set up quickly, provide detailed error information, allow varying number of soldiers to train simultaneously, and be used in a variety of training areas was developed.

Procedure:

A compass course was set up so that the outline of stakes formed two concentric rectangles. The use of concentric rectangles forced the navigator to use both azimuth and distance, the two components of dead reckoning. A computer program was written so instructors could specify course dimensions; the azimuth and distance for each leg of the course can be generated to facilitate course set-up.

Findings:

The self-correcting compass course offers opportunities for dead reckoning and land navigation training enhancement. The training advantages to this course are that it can be used in areas of limited size, that soldiers are in an easily controlled area, and that errors are self-correcting.

Utilization of Findings:

The self-correcting compass course is designed for use in both unit and institutional settings and can be used to improve dead reckoning skills. The computer program allows the trainer to specify course dimensions to accommodate virtually any training area. In addition to facilitating course set-up, the computer-generated azimuth and distance information allows for the detection and correction of soldiers' errors during dead reckoning training.

A SELF-CORRECTING COMPASS COURSE FOR TRAINING DEAD RECKONING

CONTENTS

LIST OF FIGURES

A SELF-CORRECTING COMPASS COURSE FOR TRAINING DEAD RECKONING

INTRODUCTION

Move, shoot and communicate is every soldier's mission. However, teaching the soldier to navigate accurately and effectively can be a trainer's nightmare. This is especially true when personnel at city-based Reserve Officers' Training Corps (ROTC) and Reserve components are required to teach and practice navigational techniques where training areas and/or the terrain may be limited.

Dead reckoning is the ability to navigate by following an azimuth and using a pace count. It is an easily taught land navigation skill that is useful in dense terrain, such as jungles, as well as in low-visibility conditions. Ranger and Special Forces cadre use a compass course to increase soldiers' skills and confidence in dead reckoning. For example, if a soldier training to be a Ranger receives a NO GO on land navigation, he is required to receive additional dead reckoning training.

One course is embedded in an overgrown wooded area. The course consists of engineer stakes marked with numbers, placed in the ground in a rectangular pattern. The stakes are approximately 7.62 meters apart with the overall dimension of the course approximately 38.10 meters by 68.58 meters. Each soldier is given a series of azimuths and corresponding distances and is required to move from one point to another, recording the stake number as he goes. Upon finding the required number of stakes (3 to 10), he returns to the instructor for feedback on his performance.

This type of compass course provides an effective means for evaluating a soldier's ability to follow an azimuth. However, the use of only a single rectangular array of stakes does not provide for the evaluation of both dead reckoning skills, that is, following both an azimuth and pace count. Additionally, scoring is a problem. The soldier is given all azimuths and corresponding distances prior to navigating the course. Thus if the soldier makes an error on an initial leg, then subsequent legs also will be in error.

There are at least two ways in which this course can be improved. First, to evaluate pace count, a concentric rectangle of stakes is required. This second rectangle of stakes forces the navigator to discriminate distance between two stakes along the same azimuth. The second way to improve the course is to rectify the scoring problem. This can be done by making the course self correcting. In other words, instead of giving the soldier all azimuths and corresponding distances prior to navigating the course, he is given a starting stake, from there, a new azimuth and distance is provided at each successive stake.

SELF-CORRECTING COMPASS COURSE

On an open parade ground, 200 meters by 260 meters, stakes (numbered tent pegs) were laid flush to the ground so that the soldier could not sight on the stakes. The distance between stakes was 20 meters. An inner rectangle of

stakes was added. The inner rectangle required the soldier to use both azimuth and pace count to determine the correct stake number. For example, if the target stake was a stake in the inner rectangle, but the soldier's pace count was long, he would end up between the inner and outer rectangle. Therefore, he must attend more closely to his pace, or adjust his 100 meter pace count for that terrain. Thus, a soldier's error was detected if he strayed to the left or right, or was long or short of the intended goal. Figure 1 represents the course layout.

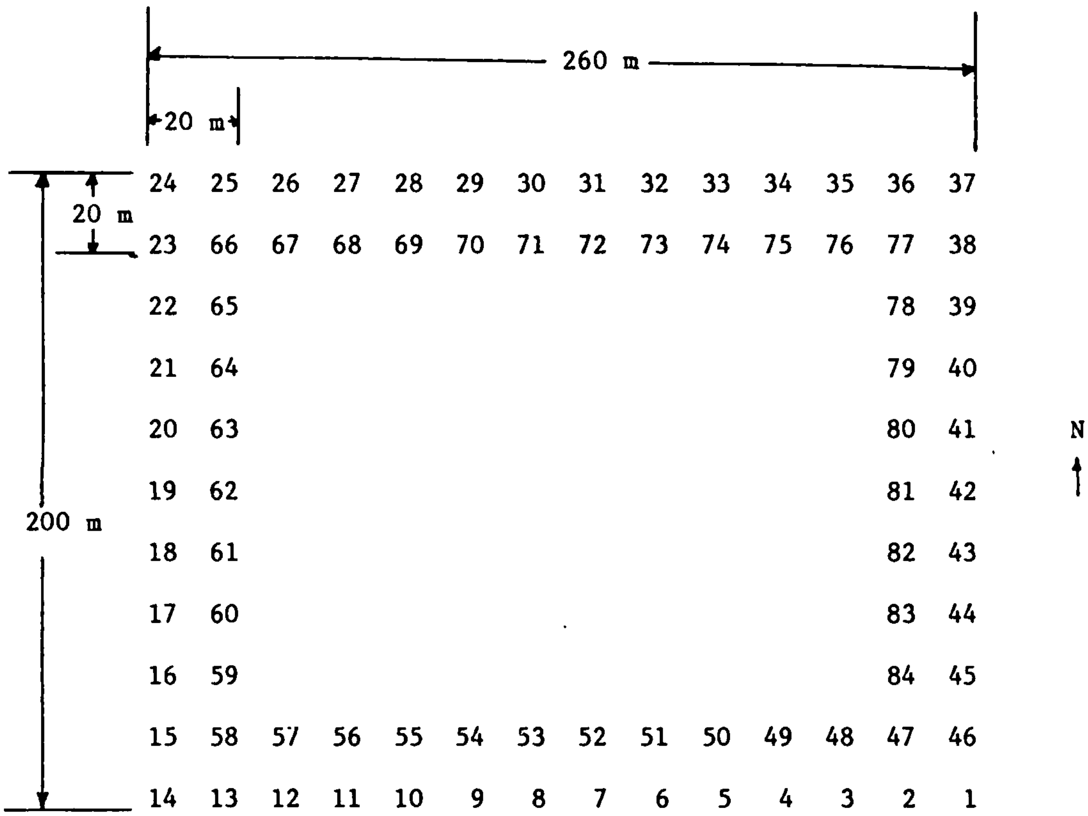

Figure 1. Self-Correcting Compass Course

To begin the field exercise, the soldier received a starting stake (1, 2, 3, . . . 84) and lane identifier (A, B, C,. . . J). From this point, he checked his lane identifier (e.g., 1A) to determine his required azimuth and distance. After traversing the distance, he marked the stake number on his score sheet.

He recorded his next azimuth and distance, which were posted on the stake, based on his original starting lane letter. The following would be located at Stake #1.

Lane		A	B	C	D	. . . . . J
Stake 1	AZ	333	305	329	312	321
	DIST	224	316	233	297	256

The course was designed to be self-correcting. For example, if the soldier went to an incorrect stake, he was given an azimuth and distance based on that stake. Upon returning to the scoring/instructor area, his errors (short/long pace or left/right drift) were identified. In the example below, a soldier was assigned to 1A and was required to find four stakes.

Route			
			Starting Stake #1
			Lane A
	AZ	333	Correct Stake #32
	DIST	224	
	AZ	158	Correct Stake #2
	DIST	215	
	AZ	309	Correct Stake #24
	DIST	312	
	AZ	94	Correct Stake #38
	DIST	261	

However, if on the first leg and each successive leg, the soldier drifted to his right, then his route resulted in the following course:

Route			
			Starting Stake #1
	AZ	333	Correct Stake #32
	DIST	224	Went to #33
	AZ	174	Correct Stake #4
	DIST	201	Went to #5
	AZ	294	Correct Stake #18
	DIST	197	Went to #19
	AZ	114	Correct Stake #3
	DIST	224	Went to #4

After outlining the intended course versus the actual course (see Figure 2), the instructor's feedback on this soldier's performance was that he continually drifted to the right and must compensate for this drift. The instructor also emphasized that this error would become much worse over extended distances.

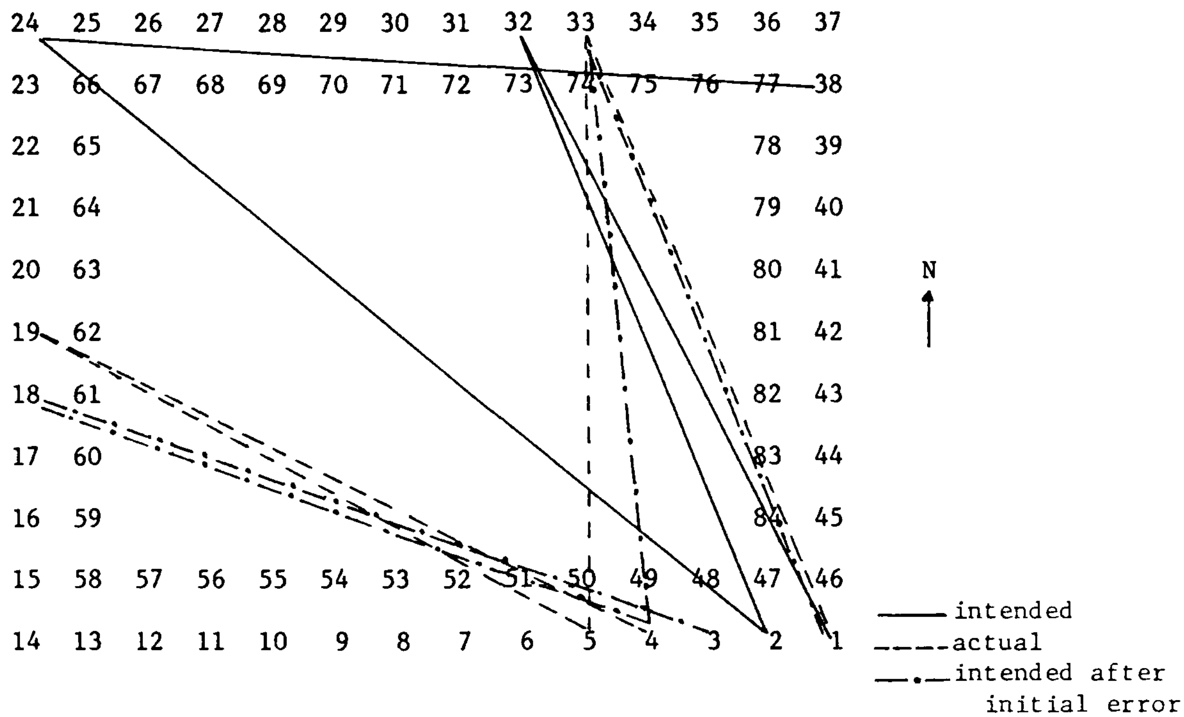

Figure 2. Intended and Actual Routes

COMPUTER PROGRAM

This course could be initiated easily and used in any training area. The following is a "flowchart" for the computer program:

1. Dimension Navigational Course matrix, Path Number matrix, Distance array, Azimuth array and "Its's Chosen" array.

2. Initialize variables

3. Ask to output to Console or Printer. Open device accordingly.

4. Get navigational course information.

5. Set up navigational course matrix and print it.

6. Get starting stake number and find coordinates (x1,y1).

7. Set error value to 0. Get proposed path stake number and find coordinates (x2,y2).

8. Find distance and azimuth.

9. Check stake number, distance and azimuth for errors. Set error value.

10. If error value is 1 then go to 7.

11. Set stake number in "its's chosen" array.

12. If more paths then go to 7.

13. Print distance and azimuth for paths per starting stake number.

14. Clear "it's chosen" array.

15. If more starting stake numbers then go to 6.

16. Print chosen stake number for paths per starting stake number.

17. END.

A computer program, written in Basic (see Appendix A), was used to generate the azimuth and distances for the compass course (see Appendixes B and C for azimuths/distances and correct stakes, respectively). Refer to Appendix D for course layout, equipment, instructions, and scoring procedures.

APPENDIX A

BASIC SELF-CORRECTING COMPASS COURSE

```
001  Rem Land Navigation Program
002  Rem Self Correcting Compass Course
003  Rem Written by William H. Greene
004  Rem
005  Dim nc$ (20,20), pn%(20,400), ds%(20), az%(20), ic%(400)
006  for y = 1 to 20: for x = 1 to 20: nc$(x,y)="": next x: next y:
      c$ = chr$(147): ch$ = chr$(19)
007  print c$;"Do you want output to": print "(p)rinter": print:
      print "(c)onsole": d = 4
008  input a$: if a$ = "c" then d = 3
009  Rem
010  Rem Main Program Logic
011  open 4, d, 7: print #4, c$;: gosub 100: gosub 200: poke 53280, 0:
      poke 53281, 0
012  print #4, ch$; c$;: for s = 1 to ns: z = s: gosub 300: x1 = x: y1 = y
013  for p = 1 to np: er = 0
014  pn%(p,s) = int(rnd(1) * (ns) + 1): if pn%(p,s) = s then 14
015  z = pn%(p,s): gosub 300: x2 = x: y2 = y: gosub 400: gosub 500:
      if er <> 0 then er = 0: goto 14
016  ic%(pn%(p,s)) = 1: next p: sl = 1: gosub 600: for a = 1 to ns:
      ic%(a) = 0: next a: next s
017  print #4, ch$; c$;: sl = 4: gosub 700: print #4, ch$;: close 4: end
018  Rem
099  Rem Navigational Course Setup
100  input "enter number of stakes east-west"; e: if e > 20 then gosub 120:
      goto 100
101  input "enter number of stakes north-south"; n: if n > 20 then gosub 120:
      goto 101
102  input "enter number of paths"; np: if np > 20 then gosub 120: goto 102
103  input "double rows-columns(1-n / 2-y)"; rc: if rc < 1 or rc > 2 then 103
104  input "enter distance between stakes"; ud
105  input "enter minimum path distance"; mp: if mp < 1 then goto 105
106  ns = (e * n) - ((e - rc * 2) * (n - rc * 2))
107  ne = (e - 1) * ud: nn = (n - 1) * ud
108  print #4, " your course is"; e; "stakes east-west and"
109  print #4, n; "stakes north-south.  You will have"
110  print #4, ns; "stakes with"; ud; "meters between each."
111  print #4, " The size of your course is"; ne; "meters"
112  print #4, " east-west by"; nn; "meters north-south.": print #4, np;
113  print #4, "Paths will be plotted from each"
114  print #4, " stake.  The minimum path distance is": print #4, mp; "meters."
116  t$ = "": for i = 1 to e: t$ = t$ +" ": next i
117  print #4: print #4, t$; "  N": print #4, t$; "W + E": print #4, t$; "  S":
      print# 4
119  return
120  print "must be less than 20": for i = 1 to 2000: next: return
198  Rem
199  Rem Setup stake# to nc$-location
```

```
200 print #4: sn = 1: for y = 1 to rc: for x = 1 to e: nc$(x,y) = str$(sn):
     sn = sn + 1: next x: next y
202 for y = (rc + 1) to (n - rc): for x = 1 to rc: nc$(x,y) = str$(sn):
     sn = sn + 1: next x
203 for x = (e + 1 - rc) to e: nc$(x,y) = str$(sn): sn = sn + 1: next x:
     next y
204 for y = (n - rc + 1) to n: for x = 1 to e: nc$(x,y) = str$(sn):
     sn = sn + 1: next x: next y
205 ln = len (nc$(e,n)): for y = 1 to n: for x = 1 to 3
206 lc = len (nc$(x,y)): if lc < ln then nc$(x,y) = " " + nc$(x,y):
     goto 206
207 print #4, nc$(x,y);: next x: print #4: next y: return
298 Rem
299 Rem Find x,y coordinates of stake#
300 for y = 1 to n: for x = 1 to e: if z = val (nc$(x,y)) then return
301 next x: next y: er = 1: return
398 Rem
399 Rem Find Distance and Azimuth
400 cx = x1 - x2: cy = y1 - y2: ds%(p) = int(sqr(cx**2 + cy**2) * ud + .5):
     if cx = 0 then er = 1: goto 410
401 az%(p) = int((atn (cy / cx) * 180 / 3.14) + .5)
402 if cx < 0 then az%(p) = 90 + az%(p): goto 410
403 az%(p) = 270 + az%(p)
410 return
498 Rem
499 Rem Error Trapping Routine
500 if er <> 0 then return
501 if x1 = x2 or y1 = y2 then er = 1: return
502 if ds%(p) < mp then er = 1: return
503 if ic%(pn%(p,s)) <> 0 then er = 1: return
504 return
598 Rem
599 Rem Print Routine for Distance and Azimuth
600 if s = 1 or f1 = 1 then gosub 800: f1 = 0
601 ls$ = "": if s < 100 then ls$ = " ": if s < 10 then ls$ = "  "
602 l1 = len (str$(s)): s$ = ls$ + mid$(str$(s), 1, l1) + " ds":
     print #4, s$;
603 d$ = "": for p = 1 to np: ls$ =" ": if ds%(p) < 100 then ls$ = "  ":
     if ds%(p) < 10 then ls$ = "   "
604 d$ = d$ + ls$ + str$(ds%(p)): next p: print #4, d$: d$ = "      az"
605 for p = 1 to np: ls$ = " ": if az%(p) < 100 then ls$ ="  ":
     if az%(p) < 10 then ls$ = "   "
606 d$ = d$ + ls$ + str$(az%(p)) :next p: print# 4, d$
607 print# 4, hl$: ifs / 19 = int (s / 19) then f1 = 1
608 return
698 Rem
699 Rem Print Routine for Chosen Stakes
700 for s = 1 to ns: if s = 1 or f1 = 1 then gosub 800: f1 = 0
711 ls$ = "": if s < 100 then ls$ =" ": if s < 10 then ls$ = "  "
712 l1 = len (str$ (s)): s$ = ls$ + mid$(str$(s), 1, l1) + " pt":
     print# 4, s$;: d$ = ""
```

```
713  for p = 1 to np: ls$ = " ": if pn%(p,s) < 100 then ls$ ="  ":
      if pn%(p,s) < 10 then ls$ = "   "
714  d$ = d$ + ls$ + str$(pn%(p,s)): next p: print #4, d$
715  print #4, hl$: if s / 27 = int(s / 27) then fl = 1
716  next s: return
798  Rem
799  Rem Page Header Routine
800  h$ = "       ": for l = 1 to np: h$ = h$ + "    " + chr$(64 + l): nest l
801  ll = len(h$) + 1: hl$ = "": for l = 1 to ll : hl$ = hl$ + "*": next l
802  for lf = 1 to sl : print #4: next lf: print #4, h$: print #4, hl$: return
ready.
```

APPENDIX B

Azimuth & distances for
200 m by 260 m area

	A	B	C	D	E	F	G	H	I	J
1AZ	333	305	329	312	349	308	354	310	276	321
DS	224	316	233	297	204	328	201	312	181	256
2AZ	310	329	312	333	315	338	318	343	321	349
DS	312	233	297	224	283	215	269	209	256	204
3AZ	290	309	329	318	333	321	338	325	343	13
DS	234	284	233	269	224	256	215	244	209	184
4AZ	281	301	318	333	321	338	325	343	329	349
DS	204	233	269	224	256	215	244	209	233	204
5AZ	294	303	321	333	325	338	329	343	349	6
DS	197	223	256	224	244	215	233	209	204	201
6AZ	311	313	329	343	321	349	325	354	17	29
DS	213	241	233	209	255	204	244	201	209	206
7AZ	319	322	329	333	349	325	354	343	17	6
DS	213	223	233	224	204	244	201	209	209	201
8AZ	319	322	333	349	326	343	338	6	17	354
DS	134	233	224	204	215	209	215	201	209	201
9AZ	331	328	338	333	343	354	349	17	11	6
DS	206	189	215	224	209	201	204	209	204	201
10AZ	333	343	17	336	354	349	31	11	6	42
DS	215	209	209	197	201	204	233	204	201	269
11AZ	349	342	343	354	6	17	11	22	31	27
DS	204	190	209	201	201	209	204	215	233	224
12AZ	347	354	17	31	349	6	11	27	42	51
DS	134	201	209	233	204	201	204	224	269	284
13AZ	354	354	6	17	11	22	31	27	35	42
DS	131	201	201	209	204	215	233	224	244	269
14AZ	6	11	27	17	31	22	35	39	48	42
DS	201	204	224	209	233	215	244	256	297	269

		A	B	C	D	E	F	G	H	I	J
15	AZ	6	24	13	29	18	34	38	43	42	51
	DS	191	197	134	203	190	216	228	269	241	284
16	AZ	99	37	32	41	48	45	51	56	54	58
	DS	243	200	139	213	241	226	256	283	272	305
17	AZ	108	45	41	49	55	52	58	62	60	65
	DS	190	198	184	213	244	223	261	295	278	286
18	AZ	49	59	107	65	108	77	110	103	107	56
	DS	134	233	272	296	253	267	234	267	209	216
19	AZ	114	55	122	61	63	69	111	81	113	94
	DS	242	159	139	205	224	279	279	263	260	261
20	AZ	70	124	66	115	77	121	72	127	103	81
	DS	234	215	197	286	267	233	253	200	267	263
21	AZ	75	131	72	120	81	128	76	118	94	125
	DS	228	213	190	272	263	223	247	295	261	244
22	AZ	90	139	77	126	86	135	148	132	143	129
	DS	224	213	134	272	261	226	189	241	200	256
23	AZ	34	133	65	151	167	135	162	132	156	129
	DS	131	241	221	206	184	255	190	269	197	284
24	AZ	94	163	153	163	149	158	145	99	141	107
	DS	261	204	224	209	233	215	244	263	256	272
25	AZ	136	145	186	141	104	153	149	153	174	130
	DS	161	244	201	256	247	215	233	224	201	312
26	AZ	95	169	153	193	135	191	132	186	149	100
	DS	221	204	209	194	233	204	297	201	233	224
27	AZ	197	149	191	145	186	141	96	153	169	133
	DS	209	233	204	244	201	256	201	224	204	269
28	AZ	96	169	174	163	136	145	197	108	158	149
	DS	131	204	201	209	201	244	209	190	215	233

		A	B	C	D	E	F	G	H	I	J
29	AZ	207	149	202	145	127	141	191	163	153	158
	DS	224	233	215	244	209	256	204	209	224	215
30	AZ	202	155	127	153	191	149	136	145	211	214
	DS	215	215	209	224	204	233	201	244	233	216
31	AZ	149	215	174	197	153	191	167	169	158	211
	DS	233	244	201	209	224	204	209	204	215	233
32	AZ	158	211	153	207	127	162	174	163	186	202
	DS	215	233	224	224	209	204	201	209	201	215
33	AZ	174	202	169	197	163	191	158	186	215	219
	DS	201	215	204	209	209	204	215	201	244	256
34	AZ	191	207	169	202	163	197	219	223	231	239
	DS	204	224	204	215	209	209	256	269	256	233
35	AZ	222	202	197	211	215	231	241	246	255	198
	DS	259	215	209	233	244	284	251	242	228	190
36	AZ	191	202	136	197	211	222	225	230	240	256
	DS	204	215	201	209	233	269	233	312	278	247
37	AZ	242	232	228	225	253	257	266	186	211	235
	DS	293	323	297	283	272	267	261	181	233	316
38	AZ	231	225	222	238	242	249	261	275	276	275
	DS	234	255	241	305	295	279	263	241	181	221
39	AZ	261	257	279	279	280	283	281	225	242	221
	DS	263	267	243	263	224	184	204	198	295	184
40	AZ	221	232	235	240	249	266	284	229	261	287
	DS	134	223	244	273	279	261	247	134	263	209
41	AZ	274	279	287	292	293	294	290	243	233	252
	DS	261	263	272	215	253	197	234	224	267	253
42	AZ	257	265	279	293	299	294	302	297	250	287
	DS	257	261	263	260	206	242	139	224	234	272

		A	B	C	D	E	F	G	H	I	J
43	AZ	297	292	307	295	311	304	252	279	255	301
	DS	268	251	200	286	184	216	190	263	228	233
44	AZ	298	308	300	311	302	315	305	319	257	295
	DS	295	228	278	213	251	193	244	184	184	286
45	AZ	309	306	312	319	315	323	265	302	275	328
	DS	256	272	241	213	226	200	221	305	241	189
46	AZ	295	312	315	326	309	331	322	336	342	284
	DS	236	269	255	216	284	206	228	197	190	247
47	AZ	297	312	318	315	322	331	326	336	347	342
	DS	268	269	241	255	228	206	216	197	184	190
48	AZ	285	302	318	331	312	336	315	342	347	6
	DS	228	281	241	206	269	197	255	190	184	181
49	AZ	264	281	301	313	326	322	331	342	336	347
	DS	201	204	233	241	216	228	206	190	197	184
50	AZ	283	294	308	322	326	342	318	347	336	354
	DS	184	197	228	223	216	190	241	184	197	181
51	AZ	311	315	322	326	342	319	347	336	354	18
	DS	213	226	228	216	190	241	184	197	181	190
52	AZ	311	322	326	342	319	336	331	18	354	347
	DS	184	228	216	190	213	197	206	190	181	184
53	AZ	323	319	331	326	336	347	342	354	6	18
	DS	200	184	206	216	197	184	190	181	181	190
54	AZ	331	336	354	323	347	342	13	6	13	29
	DS	206	197	181	189	184	190	184	181	190	206
55	AZ	342	347	6	336	354	18	34	24	38	13
	DS	190	184	181	197	181	190	216	197	228	184
56	AZ	347	6	354	13	342	13	24	38	29	42
	DS	184	181	181	184	190	190	197	228	206	241

	A	B	C	D	E	F	G	H	I	J
57AZ	354	347	18	13	6	34	29	24	45	42
DS	151	184	190	134	181	216	206	197	255	241
58AZ	18	5	24	354	13	34	45	38	48	29
DS	190	181	197	181	134	215	255	228	259	206
59AZ	37	43	41	51	32	45	56	67	60	72
DS	200	241	213	256	139	226	288	260	278	253
60AZ	45	55	49	58	41	52	63	76	67	81
DS	198	244	213	261	134	223	268	247	260	243
61AZ	56	103	63	110	76	112	104	108	53	49
DS	216	253	258	234	247	215	247	190	200	184
62AZ	113	58	66	114	67	61	76	119	122	117
DS	260	189	242	242	224	206	247	206	189	224
63AZ	70	127	68	119	91	124	76	117	95	121
DS	234	200	215	251	243	215	247	268	241	233
64AZ	72	128	76	131	104	75	120	73	81	135
DS	190	223	247	213	247	228	278	209	243	198
65AZ	79	139	80	135	35	148	104	143	99	132
DS	204	213	224	226	241	189	247	200	243	241
66AZ	34	145	174	142	167	138	162	135	156	132
DS	201	215	181	223	184	241	190	255	197	269
67AZ	84	145	84	142	174	133	157	135	162	132
DS	131	216	201	226	131	241	134	255	190	269
68AZ	107	196	138	193	135	186	132	121	156	151
DS	209	190	241	184	255	181	269	233	197	206
69AZ	193	151	186	145	198	156	174	138	167	135
DS	134	206	131	216	190	197	181	241	184	255
70AZ	122	193	151	185	145	193	167	162	212	204
DS	189	184	206	191	216	190	184	190	189	197

		A	B	C	D	E	F	G	H	I	J
71AZ		151	204	146	193	142	193	167	186	174	217
	DS	206	197	216	190	228	184	184	181	131	200
72AZ		174	185	167	193	146	193	209	214	221	139
	DS	181	161	164	190	216	184	206	216	213	184
73AZ		209	156	204	151	198	214	218	225	238	148
	DS	206	197	197	205	190	216	228	225	189	189
74AZ		214	156	209	136	167	193	193	222	225	232
	DS	216	197	206	181	184	190	184	241	255	228
75AZ		214	162	209	193	167	185	198	204	225	235
	DS	216	190	206	194	184	181	190	197	255	244
76AZ		222	204	174	193	167	193	214	231	241	260
	DS	241	197	181	190	184	184	216	284	251	224
77AZ		243	233	228	225	256	261	276	275	276	217
	DS	268	300	259	255	247	243	201	221	181	200
78AZ		221	212	231	240	243	252	265	280	229	247
	DS	213	189	256	273	268	253	241	224	213	260
79AZ		243	240	252	256	265	279	238	287	233	284
	DS	268	272	253	247	241	243	190	209	200	247
80AZ		254	292	241	243	256	275	250	298	238	265
	DS	247	215	206	263	247	241	234	253	189	241
81AZ		234	289	294	297	246	261	255	302	250	285
	DS	247	253	242	224	197	243	228	189	234	223
82AZ		288	297	304	299	307	301	311	253	255	265
	DS	253	263	216	251	230	233	184	209	228	221
83AZ		275	288	302	311	305	315	303	319	260	275
	DS	241	255	261	213	244	193	228	184	224	221
84AZ		238	304	319	306	323	309	328	312	264	264
	DS	253	283	213	272	200	256	189	241	181	201

APPENDIX C

Answer stakes for
200 m by 260 m area

	A	B	C	D	E	F	G	H	I	J
1	32	23	31	26	35	24	36	25	55	29
2	24	30	25	31	26	32	27	33	28	34
3	13	23	29	25	30	27	31	28	32	38
4	16	20	25	29	26	30	27	31	28	32
5	18	21	23	28	26	29	27	30	31	34
6	21	23	26	29	24	30	25	31	35	36
7	22	23	25	26	29	24	30	28	34	32
8	21	24	25	28	23	27	26	31	33	29
9	23	22	25	24	26	28	27	32	31	30
10	24	25	31	23	27	26	34	30	29	37
11	25	23	24	26	28	30	29	31	33	32
12	23	25	29	32	24	27	28	31	35	38
13	23	24	26	28	27	29	31	30	32	34
14	25	25	29	27	30	23	31	32	35	33
15	25	28	26	29	27	30	31	34	32	35
16	2	30	29	31	33	32	34	36	35	37
17	5	31	30	32	34	33	35	37	36	38
18	31	34	1	37	2	40	3	46	49	33
19	3	32	6	33	34	37	1	40	2	43
20	35	5	33	1	39	4	36	6	44	39
21	35	6	33	2	39	5	36	1	41	4

	A	B	C	D	E	F	G	H	I	J
22	35	7	33	3	38	6	9	5	8	4
23	33	6	35	9	12	5	11	4	10	3
24	38	12	9	11	8	10	7	39	6	41
25	15	6	14	5	40	9	7	3	12	1
26	38	10	9	15	2	14	1	13	6	39
27	14	5	13	4	12	3	38	6	9	2
28	38	9	9	7	11	3	13	40	6	4
29	14	3	13	2	12	1	11	6	4	5
30	12	4	11	3	10	2	9	1	14	15
31	1	14	6	10	2	9	4	5	3	13
32	2	12	1	11	9	4	5	3	7	10
33	4	9	3	3	2	7	1	6	12	13
34	6	9	2	8	1	7	12	15	16	18
35	12	7	6	9	10	13	18	19	21	51
36	4	6	3	5	8	11	12	14	17	21
37	17	14	12	11	20	21	23	47	7	15
38	12	10	9	15	16	18	21	25	28	26
39	20	19	25	24	26	28	27	53	15	52
40	7	10	11	13	16	20	25	53	19	27
41	21	22	24	27	25	28	26	56	23	59
42	16	16	21	25	28	26	29	27	57	23

	A	B	C	D	E	F	G	H	I	J
43	25	26	29	24	30	28	55	20	57	27
44	24	23	25	22	26	30	27	21	55	23
45	27	26	28	30	29	31	57	24	60	32
46	21	27	22	31	26	32	30	33	34	61
47	21	25	22	27	29	31	30	32	34	33
48	18	22	27	30	25	31	26	32	33	36
49	14	17	21	26	23	27	29	31	30	32
50	17	19	22	26	27	30	25	31	29	32
51	22	23	25	26	29	24	30	28	31	35
52	21	24	25	23	23	27	26	34	30	29
53	23	22	25	24	26	23	27	29	31	33
54	24	25	28	23	27	26	31	30	32	34
55	25	26	22	24	27	31	34	32	35	30
56	25	23	26	22	24	30	31	34	32	35
57	25	24	29	23	27	32	31	30	35	34
58	29	26	29	24	27	31	34	32	35	30
59	31	34	32	35	30	33	37	40	38	41
60	32	35	33	36	31	34	39	41	39	42
61	34	1	37	2	40	3	46	49	33	32
62	1	33	36	2	35	34	39	4	5	3
63	36	3	35	2	39	4	38	1	42	3

	A	B	C	D	E	F	G	H	I	J
64	34	4	37	7	43	36	1	35	38	6
65	35	5	36	5	39	3	42	7	41	4
66	33	7	12	6	11	5	10	4	9	3
67	35	6	36	5	11	4	10	3	9	2
68	41	14	3	12	2	12	1	44	7	6
69	12	5	11	4	13	6	9	2	8	1
70	43	11	4	10	3	12	7	6	15	13
71	3	12	2	11	1	10	6	9	7	15
72	6	3	5	10	1	9	12	13	15	45
73	11	2	10	1	9	12	13	15	18	45
74	11	1	10	6	3	8	7	13	14	16
75	10	1	9	6	2	5	7	8	13	16
76	11	7	2	6	1	5	9	14	17	21
77	17	14	12	11	20	21	26	25	27	53
78	9	7	12	13	16	18	21	25	55	17
79	15	14	17	13	20	23	27	26	55	24
80	23	26	56	14	17	21	59	24	55	19
81	22	23	25	26	56	17	59	28	58	65
82	22	24	27	25	28	26	29	57	58	60
83	18	21	25	23	26	29	27	30	58	61
84	20	24	29	25	30	26	31	27	56	57

APPENDIX D

COMPASS COURSE REQUIREMENTS

Materials needed:

1. Stakes (e.g., tent pegs, surveyor's stake, coffee can tops)
2. Meter measuring tape
3. Compass
4. Azimuth/distance marking at each stake
5. Score sheet for each student
6. Compass for each student
7. Pencil for each student
8. Mapped answer sheet for each student
9. Master answer sheet

Information at each stake:

1. Stake number
2. Azimuth and distance for each lane identifier

Instructions to soldiers:

1. Self-correcting compass course
2. Use azimuth and pace count
3. Given starting stake and lane identifier (e.g., 1A, 10J)
4. At each stake, given azimuth and distance for next leg
5. Write stake number on score sheet
6. After finding X number of stakes, return to scoring area

Scoring:

1. Provide course lay out for each student
2. Indicate "correct" route (this can be marked prior to training)
3. Indicate "route taken"
4. Identify errors (i.e., stray to left, right, pace too long, too short)
5. Recommend ways of correcting errors (e.g., recount 100 meter pace)